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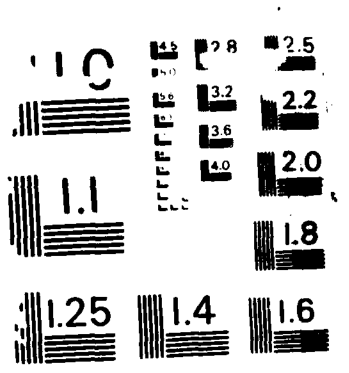

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The 'Mini' ELECTROMAGNETICS Code, or MININEC, is a method of Moments computer program for analysis of thin wire antennas ~~(reference 1)~~. A Galerkin procedure is applied to an electric field integral equation to solve for the wire currents following an approach suggested by Wilton (reference 2). This formulation results in an unusually short computer program suitable for implementation on a microcomputer. Hence, MININEC is written in a BASIC language compatible with many popular microcomputers.

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THE NEW MININEC (Version 3)

A MINI-NUMERICAL ELECTROMAGNETICS CODE

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INTRODUCTION:

The "MINI" ELECTROMAGNETICS Code, or MININEC, is a method of Moments computer program for analysis of thin wire antennas (reference 1). A Galerkin procedure is applied to an electric field integral equation to solve for the wire currents following an approach suggested by Wilton (reference 2). This formulation results in an unusually short computer program suitable for implementation on a microcomputer. Hence, MININEC is written in a BASIC language compatible with many popular microcomputers.

MININEC solves for impedance and currents on arbitrarily oriented wires, including configurations with multiple wire junctions, in free space and over a perfectly conducting ground plane. Options include lumped parameter impedance loading of wires and calculation of near zone and far zone fields. Both near electric fields and near magnetic fields can be determined for free space and over a perfectly conducting ground. The far zone electric fields and radiation pattern (power pattern) can also be determined for free space and perfectly conducting ground.

Additional radiation pattern options include a Fresnel reflection coefficient correction to the patterns, for finite conducting grounds (real earth surface impedance). Up to five changes in surface impedance due to real ground are allowed in a linear or circular "cliff" model. The cliff may take on any elevation (including zero, i.e., a flat surface), however, there is no correction for diffraction from cliff edges. In the case of a circular cliff model, the first media may include a correction for the surface impedance of a densly spaced, buried, radial wire ground screen.

The first version of MININEC given by NOSC TD 516 (reference (1), calculated currents and radiation patterns for wire antennas in free space and over a perfectly conducting ground plane. Wires attached to ground were required to intersect at a right angle and could not be impedance loaded at the connection point. Subsequent revisions corrected these shortcomings culminating in Version 2 or MININEC(2), given by Li, et al (reference 3). All previous versions of MININEC require user specification of wire end connections. However, MININEC(3) given by NOSC TD 938 (reference 4), determines connection information for itself from user defined wire end coordinates. MININEC(3) also displays the currents wire by wire, and at all wire ends, including wire junctions. MININEC(3) features an improved, faster solution routine and has been completely restructured using a more modular programming style, including the use of helpful comment statements.

BACKGROUND

The Numerical Electromagnetics Code (NEC) found in reference 5 is the most advanced computer code available for the analysis of thin wire antennas. It is a highly user-oriented computer code offering a comprehensive capability for analysis of the interaction of electromagnetic waves with conducting structures. The program is based on the numerical solution of integral equations for the currents induced on the structure by an exciting field.

NEC combines an integral equation for smooth surfaces with one for wires to provide convenient and accurate modeling for a wide range of applications. A NEC model may include non-radiating networks and transmission lines, perfect and imperfect conductors, lumped element loading, and ground planes. The ground planes may be perfectly or imperfectly conducting. Excitation may be via an applied voltage source or incident plane wave. The output may include induced currents and charges, near or far zone electric or magnetic fields, and impedance or admittance. Many other commonly used parameters such as gain and directivity, power budget, and antenna to antenna coupling are also available.

NEC is a powerful tool for many engineering applications. It is ideal for modeling co-site antenna environments in which the interaction between antenna and environment cannot be ignored. In many problems, however, the extensive full capability of NEC is not really required because the antenna and its environment are not very complex or the information sought requires only a simplified model. In addition, NEC requires the support of and access to a large main-frame computer system. These computer systems are expensive and not always readily available at remote field activities. Even when the computer facilities are available, heavy demand usage may result in slow turn around, even for relatively simple (or small) NEC runs. One viable solution is a "stripped down" version of NEC that would retain only the basic solution and the most frequently used options and which could be implemented on a mini or micro-computer with an advanced FORTRAN language capability. MININEC(3) offers many of the required NEC options, but makes use of a BASIC language that is compatible with many popular micro-computers. MININEC(3) is only suitable for small problems (less than 75 unknowns and 10 wires, depending on the computer memory and BASIC compiler).

COMPUTER REQUIREMENTS

Occasionally a technology develops which is destined to produce significant changes in the way people think and conduct their business. For many decades scientists and engineers struggled with un-manageable equations and data using trial and error techniques, employing logarithmic tables and inadequate slide rule calculations. Then came the digital computer.

In the 1950s and 60s physically large and expensive computing machines (that were relatively slow, with limited capability compared to today's standards) became available to a few. At first stored programs were accessible through direct connection of individual terminals a short distance away. The revolution had begun.

In the 70s technologists rushed to convert proven algorithms into computer programs, or to develop new algorithms suitable for efficient computer programming for use as analysis and synthesis tools by the scientific community. These tools, for the most part, required the support of large central machines. Meanwhile, slide rules were being replaced by hand held calculators with trigonometric functions, some of which could be programmed for simple repetitive algorithms.

Today, large central processing systems are being supplemented with small powerful mini and micro-computers. The development of the low cost micro-processor chip means that computers with capabilities that equal or exceed those of the earlier main-frame machines of the 50s are now available in compact size. Sizes range from suitcase, or desk top, machines (the micro-computer) to file cabinet machines (the mini-computer) that can be expanded or configured to meet specialized needs. The micro-computer is becoming more and more affordable as a personal computing tool. The micro-computer, or "home computer", is emerging as todays most important engineering and scientific tool, allowing wide-spread networking. Anyone with a micro-computer or terminal with an acoustic coupler and telephone has access to a wide variety of computing facilities around the country, as well as an almost limitless source of information.

MININEC has been written with the micro-computer in mind. But, it can also be implemented on mini or larger computers that have the BASIC language capability. However, some changes in the program may be required. Programming has been kept simple, with few machine dependent program statements, so that it will be compatible with most BASIC languages. Presently, MININEC(3) is available for IBMXT or AT compatible computers only.

NEC is suitable for both small and large numerical models. The upper limit is determined by the cost factors and memory size of the main-frame on which it resides. A model containing up to 2000 unknowns (segments) seems to be the practical upper limit. On the other hand, MININEC is suitable only for small problems. The upper limit is determined by the memory size and speed of the micro-computer employed. Practical limits seem to be 30 to 40 unknowns (current pulses) when using interpreter BASIC, due to the time required to obtain a solution. However, if one is willing to wait an hour or more for the solution, a model with 65 to 75 unknowns is possible. Serious antenna modeling requires the use of a BASIC compiler. In addition, a math co-processor board is recommended. Present micro-computer memory size limits MININEC to models with less than 100 unknowns. For problems of 100 or more unknowns, a main-frame is recommended, and in that case the use of NEC is the natural choice.

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